REMARKS

The Applicant hereby thanks the Examiner for accepting the October 29, 2002, formal drawings and for withdrawing the rejection of the claims under 35 U.S.C. §102(b). Claims 1, 2, 5, 12, and 14 are herein amended, and Claim 4 is herein canceled, without prejudice, to better encompass the full scope and breadth of the present invention, notwithstanding the Applicant's belief that the claims would have been allowable as originally filed. A marked-up version of the Claims is herewith submitted. Therefore, reconsideration of the present application in light of the foregoing proposed amendment after final rejection and these remarks is respectfully requested.

Rejection of Claim 1-19 under 35 U.S.C. §103(a).

The Examiner has rejected Claims 1-19, under 35 U.S.C. §103(a), as being unpatentable over Gardner et al. (US 5,963,810), in view of Dautartas et al. (US 6,124,158), stating:

> Gardner discloses the limitations of: ...
> depositing a first nitride film (303, fig. 3A) on a semiconductor substrate;
> depositing a high-k material (305, fig. 3B) on the first nitride (col. 5, ll. 30-64; col. 3, ll. 25-32);
> depositing a second nitride film on the high-k material (col. 6, ll. 13-20); and
> completing fabrication of the device (col. 6, ll. 1-12).
> Gardner discloses the claimed invention except:
> For where Dautartas discloses: ...
> wherein the nitride films are deposited by using an atomic layer deposition (ALD) technique (col. 7, ll. 15-30).
> ... obvious ... to form the nitride layers using an ALD technique, because this deposition technique provides excellent uniformity and surface conformity of thin insulator films.
> ... the examiner takes official notice that it is well know[n] to form a gate from a group of materials consisting essentially of polysilicon and polysilicon-germanium, and that using a photoresist is part of know[n] etching processes.

Independent Claim 1 is herein amended by inserting <u>wherein the high-k material comprises a thin metal film, and wherein the thin metal film comprises at least one material selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), and titanium (Ti)</u>. Dependent Claim 2 is herein amended by inserting <u>a material selected from a group consisting of</u> before "a silicon wafer" and by deleting [or] and instead inserting <u>and</u> before "a silicon-on-insulator (SOI) wafer." Dependent Claim 5 is herein amended by inserting <u>further</u> before comprises and by deleting [at least one metal selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), titanium (Ti), and] before "tantalum (Ta)."

Independent Claim 12 is herein amended by inserting a material selected from a group consisting of before "a silicon wafer[,]" by deleting [or] and instead inserting and before "a silicon-on-insulator (SOI) wafer[,]" and inserting wherein the high-k material comprises a thin metal film, and wherein the thin metal film comprises at least one material selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), and titanium (Ti). Dependent Claim 14 is herein amended by deleting [wherein the high-k material comprises a thin metal film,], by inserting further before "comprises[,]" and by deleting [at least one metal selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), titanium (Ti), and] before "tantalum (Ta)," and by inserting further before "comprises a metal oxide." Claim 4 is herein canceled, without prejudice, thereby rendering moot its ground for rejection on this basis.

Notwithstanding Claims 1, 2, 5, 12, and 14 being herein amended to better encompass the present invention, the Applicant respectfully traverses the Examiner's grounds for rejection on this basis. The Examiner concedes that "Gardner discloses the claimed invention except: ... for where Dautartas discloses: ... wherein the nitride films are deposited by using an atomic layer deposition technique." Gardner merely teaches depositing a silicon nitride (Si_3N_4) layer 303 and an optional silicon nitride capping layer by **sputtering** (col. 5, ll. 30-45; col. 6, ll. 40-42). In contrast, the Applicant teaches depositing silicon nitride layers 21 and 22 by an **atomic layer deposition (ALD)** technique (Spec., p. 3, l. 13, 20-21; herein amended Claims 1 and 12). As such, Gardner does not teach the presently claimed combination of method steps.

In addition, Gardner merely teaches a high dielectric constant material layer or high permittivity layer 305, comprising **barium strontium titanate ($Ba_{1-x}Sr_xO3$), tantalum oxide (Ta_xO_y), lead zinc niobate ($PbZn_xNb_{1-x}O_3$), and lead scandium tantalum oxide ($PbSc_xTa_{1-x}O_3$)**. In contrast, herein amended independent Claims 1 and 12 now positively recite the following limitation for the high dielectric constant material layer comprising the thin metal film 30, in turn, comprising species not taught, motivated, nor suggested by Gardner, even in view of Dautartas: wherein the thin metal film comprises at least one metal selected from a group consisting essentially of **zirconium (Zr), hafnium (Hf), and titanium (Ti)**. As such, the presently claimed thin metal film 30 contains a patentably distinct **group of species** *in combination with* **depositing silicon nitride layers** 21 and 22 by the patentably disctinct **atomic layer deposition** (ALD) technique.

Thus, Gardner, even in view of Dautartas, does not teach, suggest, nor motivate the present combination of method steps in herein amended Claims 1 and 12, respectively reciting:

1. **(Twice Amended)** A method of fabricating a semiconductor device, having a nitride/high-k material/nitride gate dielectric stack, comprising:
initiating formation of the nitride/high-k material/nitride gate dielectric stack by:
depositing a first ultra-thin nitride film on a semiconductor substrate, wherein the first ultra-thin nitride film is deposited by using **an atomic layer deposition (ALD) technique**;
depositing **a high-k material** on the first ultra-thin nitride film,
wherein the high-k material comprises **a thin metal film**, and
wherein the thin metal film comprises at least one material selected from a group consisting essentially of **zirconium (Zr), hafnium (Hf), and titanium (Ti)**; and
depositing a second ultra-thin nitride film on the high-k material, thereby forming a sandwich structure, wherein the second ultra-thin nitride film is deposited using an atomic layer deposition (ALD) technique;
completing formation of the nitride/high-k material/nitride gate dielectric stack from the sandwich structure; and
completing fabrication of the device. [Emphasis added.]

12. **(Twice Amended)** A method of fabricating a semiconductor device, having a nitride/high-k material/nitride gate dielectric stack, comprising:
initiating formation of the nitride/high-k material/nitride gate dielectric stack by:
depositing a first ultra-thin nitride film on a semiconductor substrate,
wherein the first ultra-thin nitride film is deposited by using **an atomic layer deposition (ALD) technique**, and
wherein the substrate comprises a material selected from a group consisting of a silicon wafer and a silicon-on-insulator (SOI) wafer;
depositing **a high-k material** on the first ultra-thin nitride film,
wherein the high-k material comprises **a thin metal film**, and
wherein the thin metal film comprises at least one material selected from a group consisting essentially of **zirconium (Zr), hafnium (Hf), and titanium (Ti)**; and
depositing a second ultra-thin nitride film on the high-k material, thereby forming a sandwich structure, wherein the second ultra-thin nitride film is deposited by using an atomic layer deposition (ALD) technique;
completing formation of the nitride/high-k material/nitride gate dielectric stack from the sandwich structure; and
completing fabrication of the device. [Emphasis added.]

As such, Claims 2, 3, 5-11, and 13-19 now subsume the limitations of the herein amended claims from which they respectively depend. Therefore, the Applicant respectfully requests that the Examiner's grounds for rejection on this basis be withdrawn.

CONCLUSION

Accordingly, Claims 1, 2, 5, 12, and 14 have been herein amended, and Claim 4 has been herein canceled, without prejudice, to better encompass the full scope and breadth of the present invention, notwithstanding the Applicant's belief that the claims would have been allowable as originally filed. A marked-up version of the Claims has been herewith submitted. Therefore, reconsideration of the present application in light of the foregoing proposed amendment after final rejection and these remarks has been respectfully requested. ***The Examiner is further cordially invited to telephone the undersigned for any reason which would advance the pending claims to allowance.***

Respectfully submitted,

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MARKED-UP VERSION OF THE CLAIMS

In the Claims:

A. **Kindly cancel Claim 4, without prejudice.**

B. **Kindly amend Claims 1, 2, 5, 12, and 14, as follows.**

1. **(Twice Amended)** A method of fabricating a semiconductor device, having a nitride/high-k material/nitride gate dielectric stack, comprising:
initiating formation of the nitride/high-k material/nitride gate dielectric stack by:
depositing a first ultra-thin nitride film on a semiconductor substrate, wherein the first ultra-thin nitride film is deposited by using an atomic layer deposition (ALD) technique;
depositing a high-k material on the first ultra-thin nitride film,
wherein the high-k material comprises a thin metal film, and
wherein the thin metal film comprises at least one material selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), and titanium (Ti); and
depositing a second ultra-thin nitride film on the high-k material, thereby forming a sandwich structure, wherein the second ultra-thin nitride film is deposited using an atomic layer deposition (ALD) technique;
completing formation of the nitride/high-k material/nitride gate dielectric stack from the sandwich structure; and
completing fabrication of the device.

2. **(Amended)** A method as recited in claim 1, wherein the substrate comprises a material selected from a group consisting of a silicon wafer [or] and a silicon-on-insulator (SOI) wafer.

5. **(Amended)** A method as recited in claim 1, wherein the thin metal film further comprises [at least one metal selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), titanium (Ti), and] tantalum (Ta).

12. **(Twice Amended)** A method of fabricating a semiconductor device, having a nitride/high-k material/nitride gate dielectric stack, comprising:

initiating formation of the nitride/high-k material/nitride gate dielectric stack by:

depositing a first ultra-thin nitride film on a semiconductor substrate,

wherein the first ultra-thin nitride film is deposited by using an atomic layer deposition (ALD) technique, and

wherein the substrate comprises a material selected from a group consisting of a silicon wafer [or] and a silicon-on-insulator (SOI) wafer;

depositing a high-k material on the first ultra-thin nitride film,

wherein the high-k material comprises a thin metal film, and

wherein the thin metal film comprises at least one material selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), and titanium (Ti); and

depositing a second ultra-thin nitride film on the high-k material, thereby forming a sandwich structure, wherein the second ultra-thin nitride film is deposited by using an atomic layer deposition (ALD) technique;

completing formation of the nitride/high-k material/nitride gate dielectric stack from the sandwich structure; and

completing fabrication of the device.

14. **(Amended)** A method as recited in claim 13,

[wherein the high-k material comprises a thin metal film,]

wherein the thin metal film further comprises [at least one metal selected from a group consisting essentially of zirconium (Zr), hafnium (Hf), titanium (Ti), and] tantalum (Ta), and

wherein the thin metal film further comprises a metal oxide.